Professor Judd has enabled me to try the action of radium emanations on specimens of this glass. Fifteen milligrammes of pure radium bromide sealed in a quartz tube were put close to a sample of the deepest green glass. In two days appreciable darkening took place, and in 10 days the darkening was very marked.

A similar experiment was tried on a sample of the purple-tinted glass; here also the action was the same as in the former case, and in 10 days the darkening was about the same. Allowing for the apparent alteration of colour caused by the initial tint of the two pieces of glass, I should say the colour produced by radium was similar in each case, and was of the same purple colour as that caused by long exposure to sunlight.]

─────────

" On the Comparison of the Platinum Scale of Temperature with the Normal Scale at Temperatures between 444° and −190° C., with Notes on Constant Temperatures below the Melting-point of Ice." By MORRIS W. TRAVERS, D.Sc., F.R.S., and A. G. C. GWYER, B.Sc. Received January 11,— Read January 26, 1905.

Introduction.—During the last few years one of us has been engaged in researches involving the accurate measurement of low temperatures. The measurements were made by means of gas thermometers, of the constant volume type, filled with hydrogen, or with helium, at an initial pressure of 1000 mm. As, however, this method proved cumbrous and inconvenient, it was decided to standardise a platinum resistance thermometer of the Callendar type against the gas thermometer, and to employ it in future investigations. The comparison of the thermometers between − 190° and 444° C. has been carried out with considerable accuracy, and as the range of temperature overlaps that investigated by Callendar and Griffiths, and by Harker and Chappuis, we have decided to publish our results, though from our own standpoint the work is only considered as preliminary to other investigations.

In expressing our results we have employed Callendar's notation. Thus, when R_0 is the resistance of a coil of platinum wire at the melting point of ice, and R_{100} is its resistance at the temperature of saturated steam under absolute standard pressure, which in the laboratory of University College, Bristol, is equivalent to 759·55 mm. of mercury at zero, the value of the coefficient of change of resistance, α, is given by

$$\frac{R_{100} - R_0}{100 R_0} = \alpha.$$

If the coil has a resistance R at the platinum temperature T_p,

$$R = R_0 (1 + \alpha'T'_p).$$

Callendar and Griffiths[*] have shown that between 0° and 444·55°, the boiling point of sulphur on the constant pressure nitrogen scale, the difference, Δ, between the platinum and the gas scales can be calculated by means of a parabolic formula,

$$\Delta = \partial \left(\frac{T}{100} - 1 \right) \frac{T}{100} ;$$

where T is the temperature (Centigrade), on the gas scale, and ∂ is a constant. Callendar has suggested that this principle should form the basis of a practical scale of temperature, and Messrs. Johnson and Matthey have taken much trouble to prepare pure platinum for the purpose. For this material α is about 0·00388 or 0·00390, and the value of ∂ about 1·5.

Previous Investigations.—Harker and Chappuis[†] have compared a set of platinum thermometers, for which the value of α was about 0·003865, with the constant volume nitrogen thermometer, and have found that the difference between the two scales of temperature can be calculated by means of Callendar's formula, taking for ∂ values between 1·54 and 1·55. The comparison was carried out over a range of temperature between $-23°$ C. and 455° C., and the errors at the higher temperatures did not exceed 0·2°.

More recently, Harker[‡] has extended this investigation, comparing the platinum thermometers with a *constant volume* nitrogen thermometer standardised at 0°, 100°, and 444·55°, the latter being Callendar's value for the boiling point of sulphur on the *constant pressure* air scale. The observations, therefore, really refer to the constant pressure air scale. In this research he employed a resistance thermometer described in the British Association Report for 1899 (p. 243), for which the value of α is 0·00389. Taking 1·51 for the value of ∂, he found that the temperatures calculated from observations of the two thermometers showed a maximum difference which only exceeded the probable error of measurement over the higher part of the range.

At the end of his paper Harker gives a table of the corresponding values of T_p and Δ, calculated on the basis $\partial = 1·50$, between $-200°$ and 1,100°. As it is well-known that the formula cannot be applied to the calculation of the difference between the two scales at low temperatures, this appears to be unnecessary and misleading.

Several independent investigators have compared platinum and gas thermometers at low temperatures, but for the reason that they did not

* 'Phil. Trans.,' A, 1891, p. 119.
† 'Phil. Trans.,' A, 1900, vol. 194, p. 37.
‡ 'Phil. Trans.,' A, 1904, vol. 203, p. 343.

employ standard platinum, or did not succeed in maintaining sufficiently steady temperatures, the results are not strictly comparable with those already referred to. The results of Dewar and Fleming, and of Olszewski have been summarised by Callendar ;* they show varying divergences from the parabolic formula, depending on the kind of platinum employed. Holborn and Wien† compared the platinum, air, and hydrogen scales at temperatures between 300° and 500°, and again at − 78° and at − 190°. They employed a platinum coil enclosed within the gas thermometer bulb, so as to minimise the error due to varying temperature. They found with platinum for which α was equal to 0·00378 the parabolic formula gave a very close approximation between − 78° and 500°, but showed a deviation of 2·3° at − 190°. We find that the deviation becomes marked even at − 78°.

Apparatus Employed.—The thermometer consisted of a coil of platinum wire about 130 cm. long, having a resistance of 7 ohms at the ice point. The ends of this wire were fused to leads about 0·3 mm. in diameter, and these leads and the ends of the compensating leads were soldered respectively to the ends of four insulated copper wires enclosed in a lead tube. The resistance was measured by means of resistances constructed by the Cambridge Scientific Instrument Co., to the design of Professor Callendar. The individual resistance coils were carefully calibrated by one of us before the experiments were commenced. As the coils were of platinum-silver alloy, for which the temperature coefficient is 0·00024, it was necessary to observe their temperature each time an observation was made, and to reduce the result to zero. The resistance plugs were cleaned before each experiment, and the zero point on the sliding resistance, which rarely varied by more than 0·0001 ohm between individual sets of experiments, or by more than 0·0005 ohm in the course of two years, was always observed. A home-made galvanometer of the two-coil astatic type was employed, and with the highest resistance in the circuit it was possible to adjust the slider with an accuracy corresponding to 0·0002 ohm. In connection with these instruments the usual arrangement of keys, etc., was employed.

The Fundamental Interval of the Thermometer.—In determining the ice and steam point the platinum coil and leads were enclosed in a glass tube containing some paraffin to the height of about 3 cm. above the coil. An identical result for the ice point was obtained by protecting the thermometer by means of a glass tube with holes in the side of it and immersing it directly in melting ice and water. The following are the results of the experiments, which need not be given in detail :—

Date and place.	Ice point measured.	Steam point measured.	α.
July, 1903, London	Three times	Twice	0·0038989
October, 1903, London ...	,,	Once	0·0038977
July, 1904, Bristol	,,	Twice	0·0038988

The probable value of the coefficient is, therefore, about 0·003899. It may be pointed out that the maximum variation in the ice point would correspond to one unit in the next place of decimals. The variations in the experimental values of α are entirely attributable to errors in the determination of the steam point. In any case an error of one unit in the last place of decimals is insignificant and amounts only to an error of :—

$$0\cdot005° \quad \text{at} \quad + \ 33° \ T_p$$
$$0\cdot05 \quad \quad ,, \quad - 200° \ T_p$$

Comparison of the Platinum and Hydrogen Thermometers in Liquid Air.—The hydrogen thermometer, employed for this purpose, has already been described by one of us in conjunction with Drs. Senter and Jaquerod.[*]   The method of working with and the degree of accuracy of the readings have been discussed in detail, and it is only necessary to state that the maximum errors never exceed 0·05° at − 190° C. At the ice point the pressure of the gas in the thermometer was about 1000 mm.

The platinum thermometer was held in a clamp so that the coil was almost in contact with the bulb of the platinum thermometer. The liquid air surrounding them was contained in a cylindrical silvered vacuum-vessel 20 cm. in diameter and 5 cm. deep, which, in the second and third set of experiments, was placed inside a somewhat larger silvered vacuum-vessel. Some liquid air was poured into the space between the two vessels, and both the opening of the annular space and the mouth of the inner vessel were plugged with sheep's wool.

With this arrangement the rate of rise of temperature as the air evaporated amounted to 0·002° per minute. And under these conditions it can safely be assumed that the temperature of neither thermometers differed from that of the bath by an appreciable amount.

It is noteworthy that under such conditions liquid air appears to evaporate from the surface and does not undergo regular fractionation.

The following are the results of our experiments :—

A. $R_0 = 7 \cdot 3322$ ohms. $\alpha = 0 \cdot 003899$.

Date.	R.	T_p.	T.H. scale.	Δ(obs.).	$\Delta(\partial = 1\cdot90)$.
June 11, 1903	1·5141	−203·53	−192·72	10·84	10·72
June 20, ,, ...	1·6170	−199·91	−189·45	10·36	10·42
June 23, ,, ...	1·5265	−203·13	−192·27	10·86	10·68
June 24, ,, ...	1·5459	−202·45	−191·71	10·74	10·65
,, ,, ...	1·5799	−201·26	−190·62	10·64	10·60
June 25, ,, ...	1·6257	−199·66	−190·18	10·48	10·39
,, ,, ...	1·6289	−199·54	−189·03	10·51	10·38
,, ,, ...	1·5215	−203·31	−192·48	10·83	10·72

In this set of experiments the liquid air was contained in a single silvered vacuum vessel.

B. $R_0 = 7 \cdot 3319$ ohms. $\alpha = 0 \cdot 003899$.

Date and time.	R.	T_p.	T.H. scale.	Δ.	$\Delta(\partial = 1\cdot90)$.
Nov. 3, 1903, 12.00 A.M.	1·5901	−200·86	−190·33	10·53	10·50
,, ,, 12.15 P.M.	1·5909	−200·82	−190·29	10·53	10·49
,, ,, 2.00 ,,	1·6072	−200·25	−189·78	10·47	10·45
,, ,, 5.00 ,,	1·6123	−200·07	−189·61	10·46	10·43
Nov. 4, ,, 11.00 A.M.	Vacuum vessel refilled with liquid air.				
,, ,, 12.15 P.M.	1·6573	−198·50	−188·14	10·37	10·30
,, ,, 2.15 ,,	1·6754	−197·86	−187·61	10·25	10·25
,, ,, 3.00 ,,	1·6781	−197·77	−187·57	10·20	10·24

C. $R_0 = 733 \cdot 19$. $\alpha = 0 \cdot 003899$.

Date and time.	R.	T_p.	T.H. scale.	Δ.	$\Delta(\partial = 1\cdot90)$.
Nov. 11, 1903, 2.00 P.M.	1·6364	−199·24	−188·84	10·40	10·36
,, ,, 3.00 ,,	1·6487	−198·80	−188·51	10·29	10·33
,, ,, 3.55 ,,	1·6583	−198·46	−188·14	10·32	10·30
,, ,, 4.50 ,,	1·6668	−198·16	−187·85	10·31	10·27

The second and third sets of experiments, in which the rate of rise of temperature was exceedingly slow, are probably the most accurate.

If we calculate the value of Δ for the Centigrade temperature − 190 for value of ∂ corresponding to 1·90 and 1·50, we find

$$\Delta \ (T = 190, \ \partial = 1\cdot90) \ .... \ 10\cdot47°$$
$$\Delta \ (T = 190, \ \partial = 1\cdot50) \ .... \ 8\cdot27°$$

This difference is of the same order as that found by other investigators.

Comparison of the Thermometers at the Temperature of Solid Carbonic Acid and Alcohol.—A mixture of solid carbonic acid and ether or rectified methylated spirit has frequently been employed as a means of maintaining a constant temperature. Olszewski states that the temperature remains constant so long as the mixture has the consistency of butter, but that as soon as ether appears on the surface, the temperature begins to rise. He gives the temperature as $-78.2°$ C.

Fig. 1.

Our experiments lead to the conclusion that to obtain the best results the solid carbonic acid should be free from lumps, and should be added to the spirit—for there is no advantage in using ether—till the mixture has the consistency of a fairly thin paste, and can be stirred with a glass rod. The stirring should be repeated at short intervals.

At the outset of the experiments we were met with the difficulty of exposing the platinum coil to the action of the mixture, and at the same time protecting it from strain during the process of stirring. When the bare wire was exposed to the mixture, it was found that the values of R_0 before and after an experiment were in every case different, and when the coil was enclosed in a glass tube with holes in the side of it, the circulation of the mixture was obstructed, and the results were discordant. The difficulty was at last overcome by surrounding the coil with a tube of wire gauze, as is shown in fig. 1. The glass and gauze tubes are shown in section, the thermometer in plan.

a, Glass tube passing inside gauze tube and connected to vulcanite head *b* of thermometer. *c*, Nickel gauze tube made rigid by binding it with wire on to the glass tube *a*, and on to thin vulcanite rings *d d*, which also serve to prevent the coil and leads from touching the gauze. *e*, Brass ring and wire grating soldered to tube.
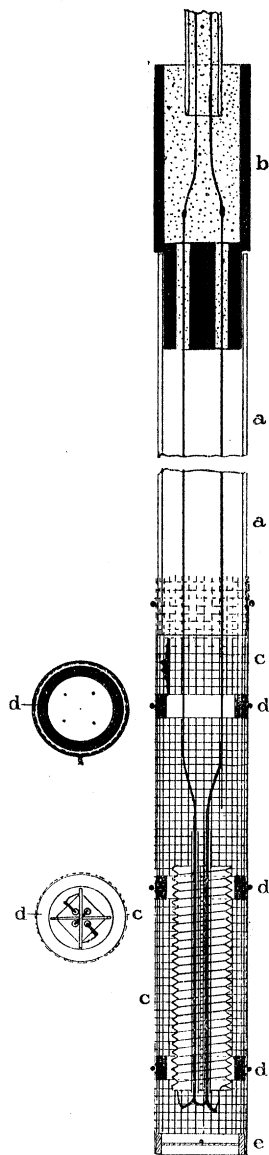
The gas thermometer was the same as was used in the liquid air experiments. As, however, the volume of the bulb was known only at 100°, 0°, and – 185° C.,* the volume at – 80 was calculated by means of a parabolic formula with two constants. We have taken as our values for the volume—

$$\begin{aligned}
100° \quad &........ \quad 24\cdot332 \text{ c.c.} \\
0° \quad &........ \quad 24\cdot262 \text{ ,,} \\
-\ 78° \quad &........ \quad 24\cdot216 \text{ ,,} \\
-185° \quad &........ \quad 24\cdot162 \text{ ,,}
\end{aligned}$$

The arrangement of the thermometers and the vacuum-vessels was the same as in the liquid air experiments, the only difference in the manner of carrying out being that the bath was stirred at intervals. The following are the results :—

A. $R_0 = 7 \cdot 3319$ ohms. $\alpha = 0 \cdot 003899$.

Date and time.		R.	T_p.	T.H. scale.	Δ.	$\partial T / \partial$ time.
Oct. 22, 1903,	3.55 P.M.	5 ·0213	−80 ·83	−78 ·25	2 ·58	
,,	,, 4.25 ,,	5 ·0230	−80 ·77	−78 ·21	2 ·57	0 ·002
,,	,, 5.00 ,,	5 ·0242	−80 ·74	−78 ·19	2 ·55	0 ·001
Oct. 23,	,, 10.00 A.M.	5 ·0276	−80 ·62	—	—	0 ·000
,,	,, 5.30 P.M.	5 ·0448	−80 ·02	−77 ·23	2 ·79	0 ·001
Oct. 24,	,, 10.00 A.M.	5 ·4336	−66 ·41	−64 ·40	2 ·01	0 ·004
,,	,, 10.20 ,,	5 ·4506	−65 ·82	−63 ·72	2 ·10	0 ·103
,,	,, 2.30 P.M.	5 ·6961	−57 ·23	−55 ·47	1 ·76	0 ·035
,,	,, 3.25 ,,	5 ·9782	−47 ·35	−46 ·04	1 ·31	
,,	,, 4.15 ,,	6 ·0160	−46 ·06	—	—	

B. $R_0 = 7 \cdot 3319$ ohms. $\alpha = 0 \cdot 003899$.

Date and time.		R.	T_p.	T.H. scale.	Δ.	$\partial T / \partial$ time.
Oct. 27, 1903,	12.20 P.M.	5 ·0194	−80 ·87	−78 ·28	2 ·59	
,,	,, 2.20 ,,	5 ·0223	−80 ·80	−78 ·27	2 ·53	0 ·006
,,	,, 4.15 ,,	5 ·0243	−80 ·73	−78 ·18	2 ·55	0 ·006
Oct. 28,	,, 10.00 ,,	5 ·0441	−80 ·04	−78 ·38	2 ·66	
,,	,, 4.00 ,,	5 ·0545	−79 ·68	−77 ·09	2 ·59	

Though these results point to the conclusion that a mixture of solid carbonic acid and alcohol varies in temperature by less than one degree over a period of more than 36 hours, it is only during the first few hours that it remains steady enough for this purpose. Taking the first three observations of each set we obtain the result—

Mean T_p.	Mean T.H. scale.	Δ.	∂ (calc.).
− 80·79°	− 78·23	2·56	1·84

* ' Phil. Trans.,' A, vol. 200, p. 138.

Taking the value for ∂, viz., 1·90, obtained by comparing the thermometers in liquid air, we obtain for Δ the value 2·64, introducing an error of less than 0·1°.

Attempts to Maintain Constant Temperatures below the Freezing Point of Water.—We have not succeeded in making comparisons of our thermometers at temperatures other than -78 and the temperature of liquid air. The use of liquefied gases such as nitrous oxide and ethylene in quantities up to 100 c.c. did not give sufficiently constant temperatures, and larger quantities could not be procured except at a prohibitive cost. Attempts were also made to compare the thermometers in baths of melting solids, such as ethyl acetate, but without success.

Comparison of the Thermometers at the Transition Point of Sodium Sulphate.—Richards and Wells* have shown that the transition point of sodium sulphate decahydrate to the anhydrous salt may be considered as a standard temperature in thermometry. They measured this temperature on three Baudin thermometers and on one Tonnelot thermometer, and found, as the mean of results which differed among themselves by 0·01°, the value 32·383 on the normal scale.

For the purpose of measuring the transition temperature on the platinum scale, we prepared some pure sodium sulphate, dried the crystals, and ground them to powder. The powder was heated in a beaker in a water-bath at about 40° C. till the mass became pasty, and was then transferred to the vessel surrounding the thermometer, which was enclosed in a tube containing paraffin oil (p. 532). The vessel containing the sulphate was a glass cylinder, 8 cm. wide and 20 cm. deep, with a round bottom. The cylinder was supported in a large thermostat, and it was found that when the temperature of the latter was kept at 32°·6 C. the temperature of the sodium sulphate remained quite steady, and was not affected by stirring.

Date.	R_0.	R.	T_p.	T_c.	Δ.
Oct. 12, 1904	7·3325	8·2704	32·799	32·383	−0·416
Oct. 13, „	„	8·2701	32·788	„	−0·405
Oct. 26, „	„	8·2706	32·805	„	−0·422

The value of ∂ corresponding to the mean value of Δ is 1·98, and it will be observed that this is identical with that obtained at $-190°$, and very close to the value at $-78°$ C., viz., 1·84. Indeed, it appears that a parabolic formula may be applied to the calculation of Δ between 30° and $-190°$ C. with a maximum error, probably not greater than 0·2° C. at about $-100°$ C. This result is mainly dependent on the

* 'Zeit. Phys. Chemie,' 1898, vol. 26, p. 690 ; 1903, vol. 43, p. 465.

2 R 2

accuracy of our determination of the transition point of sodium sulphate on the platinum scale and that of Richards and Wells on the hydrogen scale. If this result is correct it would appear that since the value 1·5 for ∂ gives for Δ 0·329 at 32·38° C., there must be at this temperature a difference of 0·08° between the constant pressure air scale and the constant volume hydrogen scale.

Comparison of the Thermometers at Higher Temperatures.—In order to make certain that our thermometer behaved normally at higher temperatures, we repeated the original experiments of Callendar and Griffiths, and obtained the same result.

The Boiling Point of Naphthalene, Benzophenone and Sulphur on the Platinum Thermometers.—The apparatus employed in these experiments was exactly similar to that described by Callendar and Griffiths.* In the case of the two organic substances the top of the glass Meyer tube was closed by a cork, and a bent glass delivery tube served to condense the vapour and conduct the liquid into a receiver. The constancy of the temperature while the substance distilled served as an indication of its purity.

The naphthalene was first crystallised from absolute alcohol, was then distilled, and subsequently redistilled before each experiment. The benzophenone (Kahlbaum) was dissolved in alcohol, water was added to the hot solution till it appeared cloudy, and then ether was added till it again became clear. On standing large crystals separated, and these were taken, dried in a desiccator, and distilled.

In the sulphur experiments we sometimes employed pure sulphur, sometimes crude roll sulphur, without observing any difference in the result.

Naphthalene.—Callendar and Griffiths† taking 444·55 for the boiling point of sulphur on the constant pressure air thermometer, measured the boiling point by means of a platinum thermometer, and found the value 217·94. Crafts‡ measured the boiling point by means of an air thermometer and found 218·06. Recently Jaquerod and Wassmer§ have determined the vapour pressure on the scale of a constant volume thermometer, filled with hydrogen at a pressure of 500 mm. at the ice point. Their results for the temperatures corresponding to pressure in the neighbourhood of 760 mm. may be expressed in the form

$$T_p = 217·68° + 0·057 \, (p - 760).$$

* 'Phil. Trans.,' A, 1891, p. 119.

† *Loc. cit.*

‡ 'Bulletin Soc. Chim.' [2], vol. 39, p. 282.

§ 'J. de Chim. Phys.,' vol. 2, p. 52.

Results ($\alpha = 0\cdot003899$).

Date.	R_0.	R.	T_p.	$T_p + \Delta(\partial = 1\cdot5)$.	T (J. and W.).
Nov. 7, 1904..	7·3325	13·4291	213·20	216·99	216·63
Nov. 11, ,, ..	7·3322	13·4490	212·91	217·64	217·28
,, ,, ..	7·3322	13·4487	212·90	217·63	217·28

It will appear that our results, calculated on this basis, are 0·36 higher than those of Jaquerod and Wassmer, and 0·10 higher than those of Callendar and Griffiths. The agreement with the latter is, however, good enough to prove our point.

Benzophenone.—Callendar and Griffiths* found the boiling point to be 305·8, while Jaquerod and Wassmer's result can be expressed in the form

$$T_p = 305\cdot44 + 0\cdot062 \ (p - 760).$$

The result of the single experiment which we carried out is as follows—

					T.
Date.	R_0.	R.	T_p.	$T_p + \Delta(\partial = 1\cdot5)$.	(J. and W.).
Nov. 18, 1904	7·3322	15·8171	296·73	306·19	305·83

The result calculated in this manner is again 0·36° higher than that of Jaquerod and Wassmer, and consequently agrees exactly with that of Callendar and Griffiths.

Sulphur.—According to Callendar and Griffiths the boiling point of sulphur on the constant pressure air thermometer is given by the expression

$$T_p = 444\cdot53 + 0\cdot082 \ (p - 760).$$

Chappuis and Harker† find for the boiling point of nitrogen on the constant volume nitrogen scale the value 445·27°.

Results ($R_0 = 7\cdot3325$, $\alpha = 0\cdot003899$).

Date.	R.	T_p.	T (C. and G.).	Δ.	∂.
Sept. 28......	19·3738	421·08°	444·37°	23·29°	1·52
Sept. 29......	19·3817	421·36	444·24	22·81	1·50
Oct. 4......	19·3806	421·32	444·06	22·74	1·49
,, ...	19·3766	421·18	,,	22·88	1·50
,, ...	19·3735	421·08	,,	22·98	1·50
,, ...	19·3825	421·39	,,	22·67	1·48

As the mean of these results we may take—

T_p.	T (C. and G.).	∂.
421·23°	444·14	1·50

* *Loc. cit.*
† 'Brit. Assoc.,' 1899, p. 245.

or taking Chappuis and Harker's value for the boiling point, which is 0·74° higher, we obtain for ∂ 1·54.

Conclusion.—As might be expected, it is possible to apply the parabolic formula of Callendar and Griffiths to the recalculation of the differences between the platinum scale of temperature and the scale of the gas thermometer, though the range through which it is applicable, and the value of the constant ∂, precludes the possibility of employing it except for interpolation. A standard scale of temperature, based on Callendar's three fixed points, using standard wire, and taking 1·5 for the value of ∂, would obviously lead to absurd results at low temperatures; and the converse may be said of our own observations. To sum the matter up, we will tabulate the results that have been referred to in this paper.

Nature of gas thermometer.	Observer.	∂.
Constant pressure air (0° to 444°)	Callendar and Griffiths	1·50
Constant volume nitrogen ($-23°$ to 445°)	Chappuis and Harker	1·54
Constant volume nitrogen standardised by constant pressure air at 444° (500° to 1000°)	Harker	1·51—1·49
Constant volume hydrogen ($-190°$ to 34°)	Travers and Gwyer	1·90

"The Arc Spectrum of Scandium and its Relation to Celestial Spectra." By Sir NORMAN LOCKYER, K.C.B., LL.D., Sc.D. F.R.S., and F. E. BAXANDALL, A.R.C.Sc. Received January 3. —Read February 9, 1905.

Very little has been published regarding the spectrum of this rare element. The records of Thalen,[*] and Exner and Haschek,[†] are the only ones previously given, the former observer confining his attention to the spark spectrum, whereas Exner and Haschek have recorded the lines under both arc and spark conditions. In the latter lists, however, no lines are given in the region less refrangible than λ 4744·0. Rowland, in his "Tables of Solar Wave-lengths," certainly ascribes a small number of solar lines to scandium, but, of course, no indication is there given as to the relation of these lines to others which occur in the scandium spectrum, either in regard to number or intensity. In connection with the work at Kensington on stellar and other celestial spectra, it has been found that in some types of spectra scandium is conspicuously represented by some of its lines, in fact,

[*] 'Öfversigt af Kongl. Vetensk. Akad. Forhandl.,' vol. 38, No. 6, p. 13.
[†] 'Wellenlängen-Tabellen für Spektralanalytische Untersuchungen auf Grund der Ultravioletten Funkenspektren und Bogenspektren der Elemente,' Leipzig und Wien, Franz-Deuticke, 1902.

FIG. 1.

2 R